Enerdata

The impact of lower oil consumption in Europe on world oil prices

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1. Study objectives

In 2007 road transport generated one-fifth of the EU's energy-related CO2 emissions: in particular, cars and light trucks alone are responsible for around 13%. In terms of energy used, road transport consumes nearly half the total oil supply to the EU-27. Although there have been significant improvements in vehicle technology in recent years (particularly with respect to engine efficiency), these have not offset the effects of traffic growth and larger car size. While EU-25 Member States reduced overall emissions of greenhouse gases by almost 5% between 1990 and 2004 (source: European Environment Agency) CO2 emissions from road transport rose during this period by 26%.

This study investigates the effects of **four different legislations** on CO2 emissions for new cars sold in the short (2010), medium (2020) and long term (2030). Various topics are explored: the reductions in European CO2 emissions and oil consumption due to the induced energy savings and substitution of road transport technologies resulting from the proposed emission standards; the impacts of such legislation on the energy security and aggregate energy bill of the EU; and, finally, the effects on international markets.

The four scenarios can be summarised as follows:

- Baseline scenario: implementation in the EU27 of the recent Commission proposal for an average emission per car of 130 g/km for all new vehicles by 2012 (the2007 average is approx. 158g/km), with subsequent further improvement.

- Scenario 2: delayed implementation in the EU27 of the Baseline objective (130 g/km) until 2015.

- Scenario 3: 2012 objective plus a 95 g/km target for 2020 in the EU27.

- Scenario 4: implementation of NGO demands – 120 g/km by 2012, decreasing to 80 g/km by 2020 and 60 g/km by 2025, in the EU27 plus the EFTA countries Norway and Switzerland.

We have assumed that such legislation diffuses to light trucks. No measure is implemented for heavy trucks.

It should be noted, however, that it is only new legislations in Europe that have been assessed, with no consideration given to potential diffusion of these new fuel efficiency standards to other regions. Although this would not significantly affect the results for Europe, it would certainly lead to a different outcome on international markets, particularly with respect to the price of oil.

In addition to this report, an Excel file has been transmitted that details all the quantitative results for each of the four scenarios studied.

2. Modelling

2.1. POLES: a general description

POLES (Prospective Outlook on Long-term Energy Systems) is a partial-equilibrium world model of the energy sector. It is based on a recursive (year-by-year) simulation of energy demand and supply with endogenous international energy prices and lagged adjustments of supply and demand to prices by world region by means of a feedback loop via international energy prices. It is a global sectoral model for the world energy system, developed as a hierarchical structure of interconnected sub-models at the international, regional and national level.

In Fig. 1: "Fossil fuel Imports/Exports" (with "fuel" singular) is better.

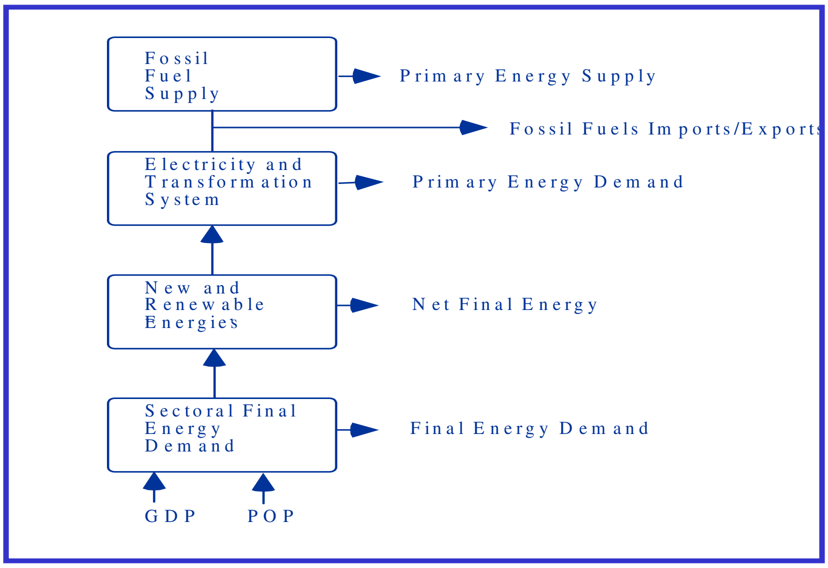

Figure 1: POLES model – regional energy demand

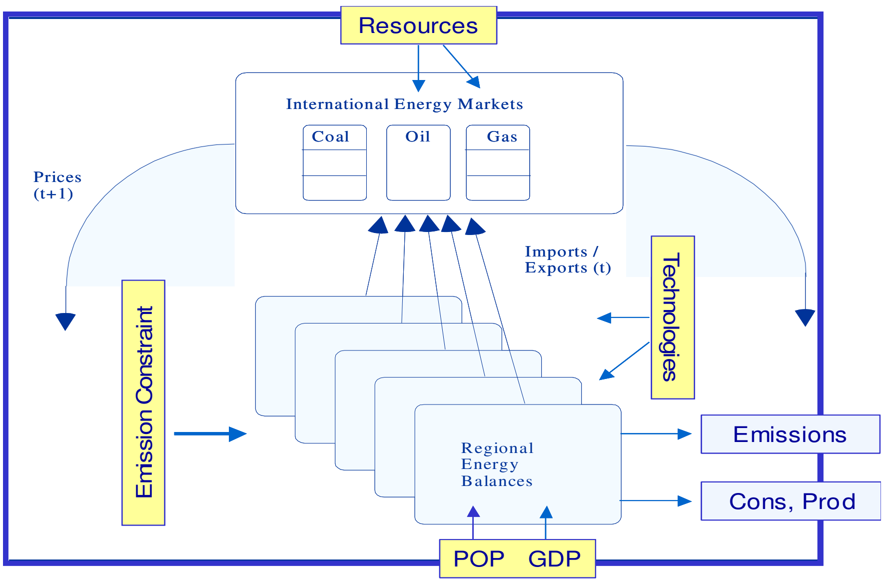

Figure 2 : POLES model – international energy balance

2.1.1. Structure of the model

In the current geographic disaggregation of the model, the world is divided into **47 countries or regions**, with a detailed national model for each Member State of the European Union (25), four industrialised countries (USA, Canada, Japan and Russia) and five major emerging economies (Mexico, Brazil, India, South Korea and China). The other countries/regions of the world are dealt with in a simplified but consistent demand model.

Region	Sub-Region	Countries
North America		Unites States, Canada
Europe	EU-15 EU-25 EU-27	> Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, UK, Turkey > Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovak Republic, Baltic States
Japan – South Pacific	South Pacific	Japan, Australia & New Zealand
CIS		Russia, Ukraine
Latin America	Central America South America	Mexico Brazil
Asia	South Asia South-East Asia	India China, South Korea
Africa / Middle-East	North Africa Sub-saharan Africa Middle-East	Egypt, Algeria-Lybia, Morroco-Tunisia Gulf countries

Figure 3: POLES model – regional coverage

For each region, the model articulates **five main modules** dealing with:

- final energy demand by main sector
- new and renewable energy technologies
- Hydrogen and Carbon Capture and Sequestration technologies and infrastructures
- the conventional energy and electricity transformation system
- fossil fuel supply.

While simulation of the different individual energy balances allows for calculation of import demand / export capacities by region, horizontal integration is ensured in the Energy Markets module, the main inputs of which are the import demand and export capacities of the various regions.

Only one world market is considered for the oil market (the "one great pool" concept), while three regional markets (America, Europe, Asia) are identified for gas and coal, in order to take into account different cost, market and technical structures. The comparison of import and export capacities and the changes in the Reserves/Production ratio in each market determine the price variation in subsequent periods.

In the detailed demand model for the main countries or regions, energy consumption is disaggregated into homogeneous sectors, permitting identification of the key energy-intensive industries, the main transport modes and residential and tertiary activities. The following are distinguished: Steel industry; Chemical industry; Non-metallic mineral industries; Other industries; Road passenger transport; Road freight transport; Rail passenger transport; Rail freight transport; Air transport; Residential sector; Tertiary sector; and Agriculture.

Each demand equation combines a revenue- or activity-variable elasticity, a price elasticity, technological trends and, where appropriate, saturation effects. Particular attention has been paid to the dynamic impacts of prices.

Recent developments in the POLES 5 version of the model have also allowed representation of the development of Very Low Energy/Emission end-use technologies (VLE). By moving beyond the concept of energy efficiency through new concepts and product designs, these technologies may foster considerable improvements in energy performance in the two strategic sectors of buildings and road vehicles.

2.1.2. Electricity and Transformation System module

This module is connected to the road transport system through power consumption in electric and plug-in hybrid vehicles. Indirect emissions from power production for road transport are also reported in the results (Appendix 2, Table 5).

In every country the power generating system is not just one of the main energy-consuming sectors but is also probably **the major sector for inter-fuel substitution**. A final characteristic is that, because of the particularly long lifetime of generating plant, this sector exhibits much higher price elasticities in the long term than in the short term.

To allow for capacity constraints in the power production system, the module simulates the evolution of existing capacities during each period as a function of plant development decisions taken in preceding periods and thus as a function of the anticipated demand and costs at the corresponding time. The current version of the model identifies around twenty-five power generation technologies, conventional as well as new. Carbon Capture and Sequestration has also been introduced for two coal and one gas generation technology.

Among these technologies, the POLES model identifies renewable energy sources characterized by technical potentials that may cap their development (resource availability: land, wind, biomass, solar irradiation and so on): onshore and offshore wind, solar power plants, biomass thermal power plants and biomass gasification.

2.1.3. Hydrogen production and use

The POLES model uses a full description of future hydrogen production, transport and consumption technologies. As hydrogen is merely an energy carrier, great attention is paid to the description of the many H2 production technologies available, to transport costs via new infrastructures and to the interfaces of the H2 system with the conventional electricity system. Two hydrogen end-use markets are considered: distributed electricity with cogeneration and Very Low Emission road vehicles with fuel cells (direct injection in a conventional ICE is also considered).

Within the time frame of the present study (horizon: 2030) hydrogen does not emerge as a major option, however.

2.1.4. International Energy Prices module

In the current version of the model, the basis for international oil price modelling combines a Target **Capacity Utilisation Rate model for the Gulf countries** and the **global oil R/P ratio** as a long-term explanatory variable. This reflects the fact that most applied analyses of the oil market point to the shorter-term variations or shocks in the oil price, as experienced in the seventies and eighties, for example, can be explained by the development of under- or over-capacity in the Gulf region. Coal and natural gas prices are computed for each of the three main regional markets using regional coal and gas trade matrixes and price variations linked respectively to coal production capacities and to the gas R/P ratio of the key residual producers in each region.

2.1.5. Inputs

The energy balance data for the POLES model have been extracted from an international energy database that also includes international macro-economic data on GDP, the structure of economic activity, deflators and exchange rates. Technico-economic data (energy prices, equipment rates, costs of energy technologies and so on) have been gathered from both international and national statistics. Regular updates of the database are provided by ENERDATA.

2.1.6. Outputs

The model output consists of endogenous international energy prices and all relevant information on energy flows for each country / region, in a structure similar to that of a standard IEA-type energy balance. In addition, the POLES model provides detailed quantitative results on technological developments in various sectors: power and hydrogen production, vehicle fleets and types of building.

2.2. Transport module

The road transport sector is composed of three parts: **cars**, **light trucks** and **heavy trucks**. In each of these, competition between **five types of vehicles** is described, allowing for the potential introduction of hydrogen and/or electricity as a vehicle energy source. The technologies considered in this exercise are:

- Conventional ICE (oil, biofuels)
- Plug-in hybrid (oil, biofuels, power)
- Electric vehicle (power)
- Hydrogen fuel cell vehicle (hydrogen)
- Hydrogen in conventional ICE (hydrogen)

The POLES definitions of several vehicle types require further clarification:

- the "Conventional ICE" vehicle is defined as a vehicle running on conventional liquid fuels only, i.e. oil and biofuels. In this case the "Prius"-type hybrid vehicle is considered a Conventional ICE, since the rechargeable energy storage system does not plug into the power grid but is merely a means of improving fuel efficiency;
- conversely, a "plug-in hybrid" electric vehicle can be recharged from the electric power grid and runs on both electricity and conventional liquid fuels;
- in the "Hydrogen in conventional ICE" vehicle, the hydrogen is burned in an engine in fundamentally the same way as in traditional petrol cars;
- in fuel-cell conversion, the hydrogen is reacted with oxygen to produce water and electricity, with the latter being used to power an electric traction motor.

2.2.1. Modelling the road transport sector

The POLES model simulates demand for road transport in terms of "vehicle-km". It depends on both the current level of vehicle technologies and the annual distance travelled. The former depends on the revenues per capita, the latter mainly on fuel price.

Each year, new vehicles are needed to replace scrapped ones and to satisfy new customer demand. The new vehicles compete for this market based on their total cost to the user, which has a fixed cost component (investment costs discounted over vehicle life-time) and a variable cost component, which depends on fuel efficiency and fuel price.

The equations are provided in Appendix 1.

Biofuels compete on the fuels market for conventional ICE and plug-in hybrids based on their cost to the consumer (as compared to the cost of petrol). No dedicated policy is considered here.

Finally, it should be noted that "Conventional ICE" consumes an "average fuel" composed of petrol and diesel, in a ratio depending on the country concerned.

2.2.2. Integrating emission targets for new vehicles

In this study we introduced CO2 emissions targets on all new vehicles. These are assumed to be defined for the entire fleet and are calculated as the average CO2 emissions of each vehicle type weighted by its market share. In practical terms this amounts to assuming that automakers will have the option of selling electric or hydrogen vehicles alongside Conventional ICE vehicles to achieve their average per-vehicle emission target.

These targets impact directly on the unit consumption of Conventional ICE vehicles. In contrast, the unit consumption of each of the four alternative vehicles remains the same across the different scenarios and is an exogenous variable taken from the TECHPOL database (developed at the French energy research institute LEPII-EPE).

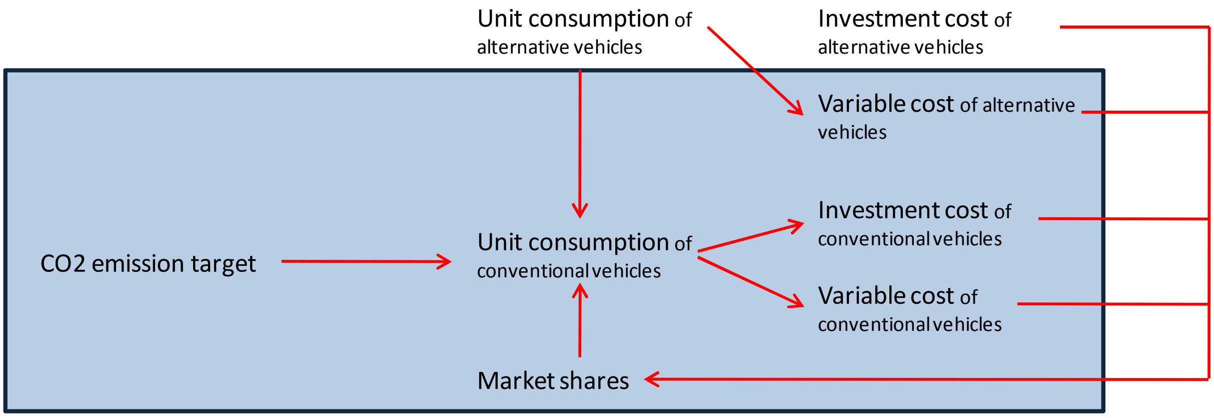

Figure 4: Integrating emission targets for new vehicles

Reduced oil consumption proves to lead to lower variable costs for Conventional ICE vehicles (direct effect and impact of a consequently slightly lower international oil price).

At the same time, though, the development of more efficient standard "average" vehicles (size and weight effects are not considered in this study) due to implementation of the new emission standards and not to purely endogenous technological developments through price effects, implies an **extra investment cost** for these vehicles. This extra cost has been derived from a study carried out for the French Ministry of Environment (*Etude de quatre instruments réglementaires visant les emissions de CO2 des véhicules particuliers*, Ecofys/Enerdata, July 2007).

It is important to reiterate that no size or weight effects induced by legislation on fuel efficiency are considered in this study and that automakers produce the same type of "average" vehicles in each of the four scenarios. One way to secure the emission target would indeed be to reduce the average power requirement of new cars, by producing small cars for dedicated urban use, for instance. However, in the absence of detailed modelling of urban areas and of the related development potential of such vehicles, and in the absence of a precise relationship between fuel efficiency and car size/weight, we have simplified matters by considering only the "same comfort/uses of vehicles but with extra costs" option.

This extra cost alters the relative competitiveness of the various vehicles types and thus their share in the new vehicles market.

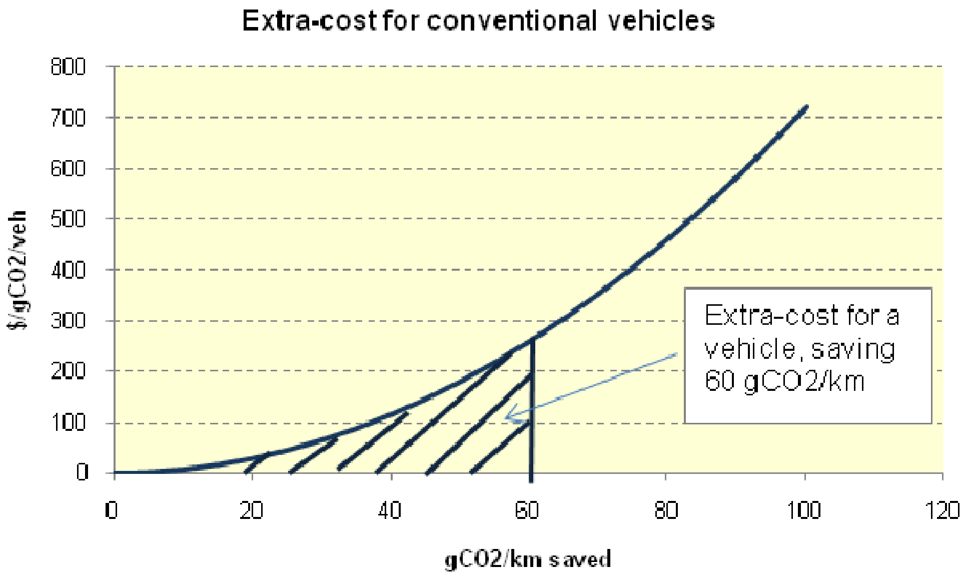

Figure 5: Extra cost of a fuel-efficient conventional vehicle

Finally, it should be noted that the CO2 emission target has been **extended to light trucks**. The calculated extra reduction in oil consumption in new conventional cars due to emission standards has therefore also been applied to the theoretical oil consumption of new light trucks.

2.2.3. CO2 emissions

In this study the emission standards apply only to direct emissions. Direct CO2 emissions are simply calculated by applying an emission coefficient to the energy content of the oil consumed in Conventional ICE and plug-in hybrid vehicles. Direct emissions from biofuels are taken to be zero.

Indirect emissions, whether from power, hydrogen or biofuels production, are reported in the results, though (Table 5, Appendix 2).

2.2.4. Assumptions

To summarize, the following assumptions are employed in the scenarios:

- The CO2 emissions of newly sold cars have an impact on the unit consumption of new conventional vehicles only.
- The unit consumptions of alternative vehicles are considered exogenous. For example, possible improvements to plug-in hybrids are unconnected to improvements to conventional vehicles.
- The mean proportion of oil consumed in a plug-in hybrid vehicle is held constant (at around 67% of the total energy consumed: power is used twice more per km, but electric batteries are four times more efficient).
- CO2 emissions are defined as direct emissions from oil combustion: biofuels combustion is carbon-neutral.
- The CO2 content per energy unit for oil is taken constant over the simulation period.
- All countries converge to the same objective in terms of CO2 emission per km, regardless of their current emission level (the underlying assumption being that fleets tend to converge to a European average).
- The development of biofuels on the European market does not depend on legislation and dedicated policies, only on oil prices.
- CO2 emissions have been modelled as a linear trend up to the target years. Subsequently, POLES takes charge of the emissions profiles, through the price effect in particular.

2.2.5. Update of data

The data relating to road transport have been updated to 2006 from the European ODYSSEE database. The data collected in POLES and updated for the present study are: stock of motorcycles, stock of new cars, (fuel and energy) consumption of road transport, consumption of cars, consumption of motorcycles and consumption of light vehicles in each EU-27 country.

The ODYSSEE database is available at http://www.odyssee-indicators.org/

3. Results

3.1. Europe : road transport and energy consumption

Setting targets for vehicle emissions has two simultaneous effects on the car fleet: it modifies fleet composition through the development of non-emitting vehicles and at the same time leads to the diffusion of more efficient oil-powered vehicles. The targets will impact on road transport emissions (both direct and indirect) as well as on total European oil consumption.

3.1.1. Vehicle consumption

Table 1 below shows the evolution of consumption per vehicle for the entire fleet (and not only for the new cars to which the emission constraint applies). The figures are given as averages in toe/Mkm: this unit is makes it easier to compare various kinds of fuel and energy consumption (petrol, electricity, etc.).

As mentioned earlier, the unit consumption of alternative vehicles is not affected by the emissions constraint and therefore remains constant across the various scenarios (and fairly stable over time).

On the other hand, the consumption of "conventional" vehicles evolves significantly over time and in the various scenarios. The lowest constraint leads to an average fuel consumption per vehicle that by 2030 is 25% lower than the 2007 figure (44 toe/Mkm in Scenario 2 vs. 59 toe/Mkm), while Scenario 4 leads to an improvement of 43% in 2030, at 33.4 toe/Mkm (25% below the Scenario 2 result in 2030).

	2007	**2010**				**2020**				**2030**			
toe/Mkm		Bas.	S2	S3	S4	Bas.	S2	S3	S4	Bas.	S2	S3	S4
Conventional	**58.8**	55.6	56.2	55.6	55.0	47.0	47.9	43.7	41.3	43.6	44.1	37.2	33.4
Plug-in hybrid	**27.1**	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	26.0	26.0	26.0	26.0
of which oil cons.	**18.2**	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	17.4	17.4	17.4	17.4
Electric	**12.1**	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	11.9	11.9	12.0	11.9
Hydrogen fuel cell	**18.1**	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	17.0	17.0	17.0	17.0
Hydrogen combustion	**60.5**	60.5	60.5	60.5	60.5	60.5	60.5	60.5	60.5	57.5	57.5	57.6	57.5

Table 1: Unit consumption per vehicle type

3.1.2. Car fleet composition

The implementation of emission targets for new cars will lead not only to more efficient conventional vehicles, but also to growing diffusion of non-emitting vehicles: as constraints on CO2 emissions increase over the simulation period, sales of oil-based vehicles slow down, while vehicles running on alternative fuels increase their market share.

Thus, in 2030 the percentage of conventional cars decreases to 88% in Scenario 2 (the least constraining) compared with 66% in Scenario 4 (the most stringent). The main competitor for oil-based ICE vehicles appears to be the **plug-in hybrid**, running on both oil and power, followed by purely electric vehicles. The development of plug-in hybrids stems mostly from their low investment costs.

A detailed table on fleet composition is provided in Appendix 2, Table 9.

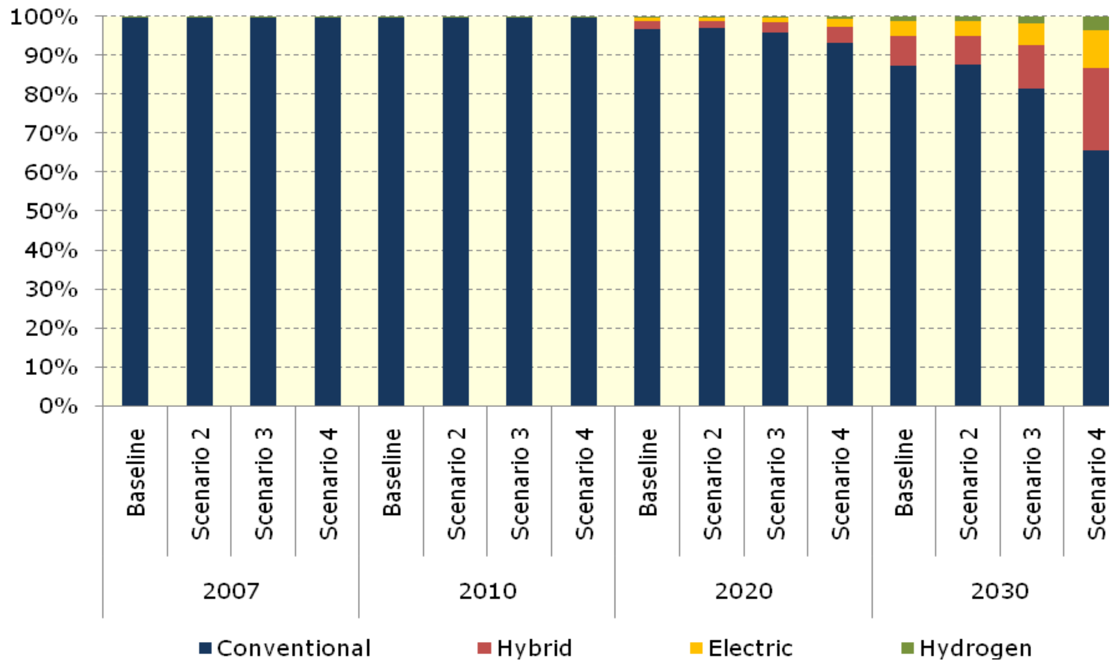

Figure 6: Car fleet composition in the EU27

3.1.3. CO2 emission profiles

A 130g/km average CO2 emission in 2012 brings about the same profile as a 130g/km average CO2 emission in 2015. Differences become more significant in Scenarios 3 and 4. Scenario 3 points to 4690 Mt total energy CO2 emissions in 2030: a 1.5% decrease compared to the Baseline figure for the same year (4760 MtCO2). In Scenario 4 total CO2 emissions decline by 2.5% in 2030 compared with the Baseline, standing at 4643 Mt CO2.

Over time and with the implementation of vehicle emission standards, total road transport emissions will decrease, even though indirect emissions (due mainly to power production for electric and plug-in vehicles) are set to increase. In the Baseline case, the emissions induced by road transport amount to 858 MtCO2 in 2030 (including 34 MtCO2 of indirect emissions) and to 724 MtCO2 in Scenario S4 (including 87 MtCO2 of indirect emissions), as shown in Table 2 below.

An interesting point to focus on is the share of road transport emissions (both direct and indirect) in the aggregate CO2 emissions of the EU. In 2007 road transport was responsible for 21% of total EU CO2 emissions. In the various scenarios this share declines, but slower or faster, depending on the constraints. In the Baseline this share falls to 18% in 2030, compared with 15.6% in Scenario 4. In the Baseline road transport emissions in 2030 are reduced by 3.5% compared with 2007. In Scenario 4 the reduction is 19%. This latter result comes closer to European aggregate CO2 emission targets.

	2007	**2010**				**2020**				**2030**			
Mt CO2		Bas.	S2	S3	S4	Bas.	S2	S3	S4	Bas.	S2	S3	S4
Total emissions	**889**	**887**	**893**	**888**	**881**	**872**	**880**	**835**	**804**	**858**	**863**	**782**	**724**
Direct	889	887	893	887	881	863	872	824	787	823	829	732	637
Indirect	0	0	0	0	0	9	8	11	18	34	34	50	87

Table 2: Road transport CO2 emissions (direct and indirect)

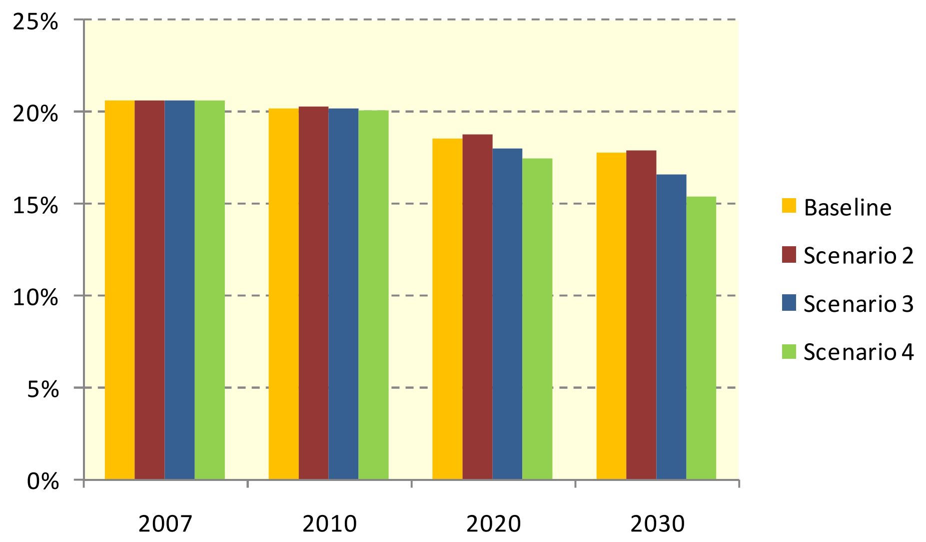

Figure 7: Share of road transport in total EU27 CO2 emissions (direct and indirect)

3.1.4. Oil consumption

The scenarios support the notion of **declining oil consumption in the transport sector**. Nevertheless there is a very significant disparity among the scenarios, with the decline particularly visible in Scenario 4. In 2007 oil consumption dedicated to cars and light trucks stood at 206 Mt, accounting for about 35% of total EU oil consumption. In the Baseline scenario this figure falls to 167 Mt in 2030 (28.5% of total EU oil consumption). In Scenario 4 total oil consumption by light trucks and cars is down to 109 Mt at the end of the simulation, around only half the amount consumed by these light-duty vehicles in 2007.

To sum up, the Baseline scenario as well as Scenario 2 suggest a **20% reduction in oil consumption for this category of vehicles, Scenario 3 a 30% reduction and Scenario 4 a 40% reduction**. Scenario 4 thus represents a 58 Mtoe saving in 2030 compared with the Baseline scenario.

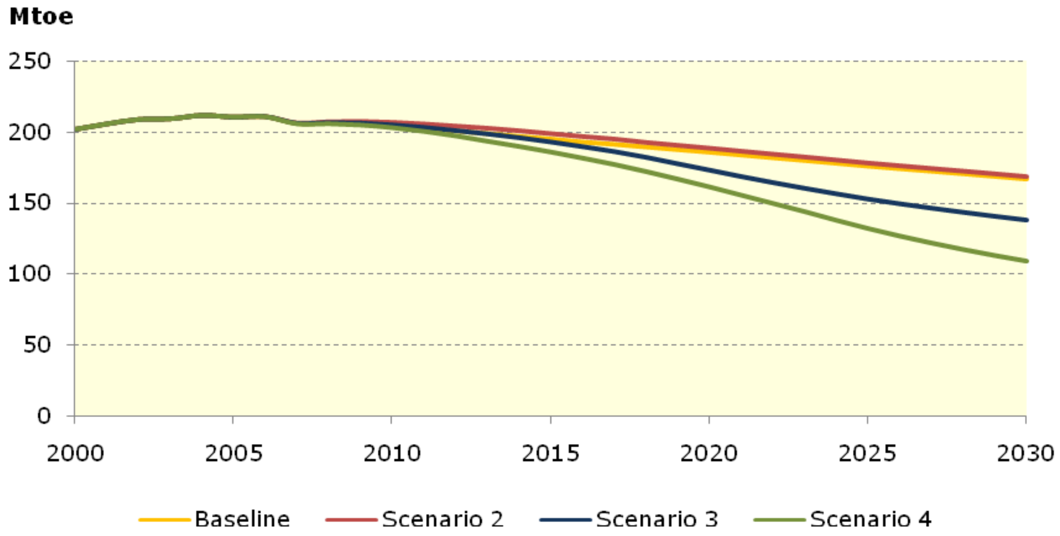

Figure 8: Oil consumption by cars and light trucks

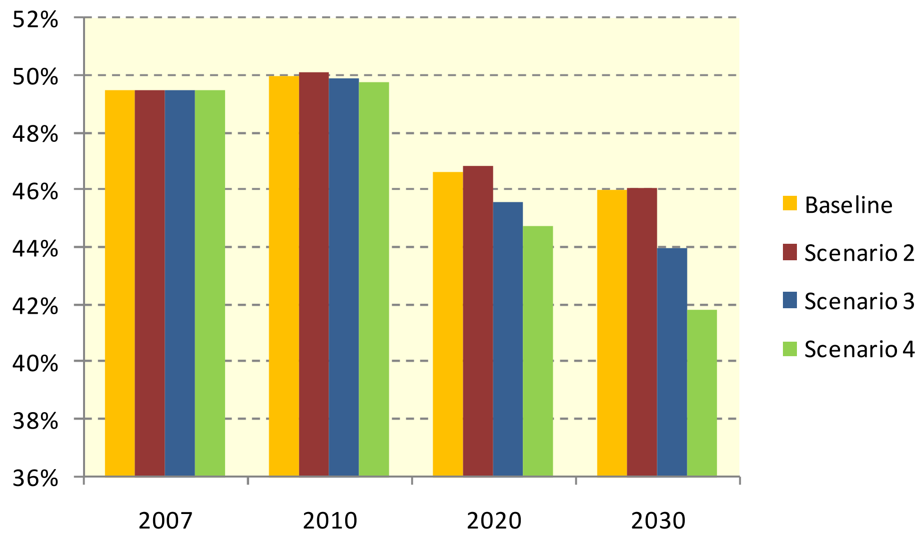

Figure 9: Share of cars and light trucks in total EU27 oil consumption

3.1.5. Energy mix

In terms of primary consumption, greater use is made of natural gas and coal in Scenario 4 in 2030 than in the Baseline. In fact, the road transport sector consumes 16 Mtoe of electricity in the former and 6 Mtoe in the latter. This additional electricity consumption is provided mainly by gas and coal plants, leading to the already cited differences between the scenarios in terms of primary energy consumption.

In terms of final energy consumption, fossil fuels (excluding oil) are not sensitive to fuel efficiency standards for cars. The consumption of electricity and hydrogen will rise.

As a result, and in the absence of climate related policies in other sectors, CO2 emission targets for new cars will increase the role of coal in the European energy system in the future, even though total attendant emissions will still fall (see point 3.1.2 above). Of course, generalized policies on CO2 would reduce coal use and foster carbon-neutral technologies in the power sector.

Mtoe		Oil	Natural Gas	Coal	Biomass	Others
2007	Current	661	412	380	97	287
2010	Baseline	653	426	402	99	293
	Scenario 2	655	426	402	99	293
	Scenario 3	653	426	402	99	293
	Scenario 4	651	426	402	99	293
2020	Baseline	670	532	425	126	270
	Scenario 2	673	532	425	126	270
	Scenario 3	657	533	426	126	270
	Scenario 4	645	534	428	126	270
2030	Baseline	644	568	468	157	295
	Scenario 2	645	568	468	157	295
	Scenario 3	614	570	473	157	297
	Scenario 4	583	576	484	157	301

Table 3: Primary energy consumption in the EU-27

3.2. Impact on European imports

This study also permits assessment of energy security and the related issues of energy independence, energy imports and energy-exporting countries.

The evolution of energy security is measured in terms of energy independence on the one hand and the attendant volumes of imported fuel on the other.

Energy independence is simply calculated as the ratio:

Energy produced domestically / Energy consumed

The four scenarios indicate a slowdown of oil imports in 2010 and then an increase. The energy independence ratio grows from 18% in 2007 to 23% in 2010. In 2020 and 2030 this indicator equals 17% and 13%, respectively. This can be explained by the oil production profiles of European producer countries like the United Kingdom, the Netherlands and Norway. By 2012-2015 these countries will reach a peak in output, immediately entering into decline thereafter. From then on, **the EU will have to import far more** compared to its consumption.

The legislation on new cars has some impact on energy security. Even if in Scenario 4, with the most aggressive target, EU gains only 1.2% in terms of oil independence in 2030, on the other hand the volume imported is then significantly lower (-60 Mtoe in 2030, around 10% of the case in Scenario 2, with the highest oil imports).

However, this volume represents only a very small fraction of the world energy market and oil output by the major producers will consequently be scarcely affected. For example, production in the Gulf states decreases from 31.4 Mbl/d in 2030 in the Baseline scenario to 31 Mbl/d in Scenario 4.

%	2007	2010 Bas.	2010 S2	2010 S3	2010 S4	2020 Bas.	2020 S2	2020 S3	2020 S4	2030 Bas.	2030 S2	2030 S3	2030 S4
Total energy independence	**50%**	**53%**	**53%**	**53%**	**53%**	**48%**	**48%**	**48%**	**49%**	**45%**	**45%**	**46%**	**46%**
Energy consumption (Mtoe)	*1837*	*1874*	*1876*	*1874*	*1872*	*2024*	*2026*	*2011*	*2003*	*2132*	*2134*	*2111*	*2102*
Fossil fuel imports (Mtoe)	*911*	*873*	*874*	*873*	*871*	*1050*	*1053*	*1038*	*1030*	*1173*	*1175*	*1150*	*1133*
Oil	18%	23%	23%	23%	23%	17%	17%	17%	18%	13%	13%	14%	14%
Oil consumption (Mtoe)	*661*	*653*	*655*	*653*	*651*	*670*	*673*	*657*	*645*	*644*	*645*	*614*	*583*
Oil imports (Mtoe)	*544*	*504*	*506*	*504*	*502*	*557*	*559*	*544*	*532*	*559*	*560*	*529*	*499*
Gas	47%	48%	48%	48%	48%	38%	38%	38%	38%	28%	28%	28%	28%
Gas consumption (Mtoe)	*412*	*426*	*426*	*426*	*426*	*532*	*532*	*533*	*534*	*568*	*568*	*570*	*576*
Gas imports (Mtoe)	*218*	*220*	*220*	*220*	*220*	*331*	*331*	*331*	*333*	*407*	*407*	*409*	*416*
Coal	61%	63%	63%	63%	63%	62%	62%	62%	61%	56%	56%	55%	55%
Coal consumption (Mtoe)	*380*	*402*	*402*	*402*	*402*	*425*	*425*	*426*	*428*	*468*	*468*	*473*	*484*
Coal imports (Mtoe)	*149*	*148*	*148*	*148*	*148*	*163*	*163*	*163*	*165*	*207*	*207*	*211*	*218*

Table 4: Energy independence

European gas imports follow roughly the same pattern as oil imports: they increase substantially from 2020 onwards, with energy independence declining to 38% in 2020 and then 28% in 2030 (versus 47% in 2007). It should also be noted that in all scenarios nearly 60% of the gas is imported from Russia by 2030, underlining potential energy security concerns.

Regarding coal, Europe remains less dependent on imports, which represent only 45% of total consumption by 2030 (40% today). The constraint on vehicle emissions does not change the picture significantly.

Still, it appears that implementation of emission standards will lead to increased gas and coal consumption as well as increased imports thereof. Indeed, this comes from the accelerated development of plug-in vehicles (either hybrids of purely electric). More electricity is thus generated, which appears to be mainly from gas and coal in these scenarios (which give no consideration to specific carbon policies in other sectors). In Scenario 4 coal consumption increases by 3.5% compared with the Baseline and gas consumption by 1.5%. In the most "electric" scenario, electricity consumption by road transport represents only 4% of total power consumption, so the impact on gas and coal consumption and imports remains modest (see

Table 12). Energy independence thus remains roughly constant in all the various scenarios.

4. Impact on world oil prices and Europe's energy bill

4.1 International oil prices

➢ *Explanation of oil prices*

One key feature of the POLES model is that it estimates **international equilibrium market prices for oil and gas, based on an explicit description of the fundamentals of each international market and a detailed representation of reserve and resource constraints.** The model calculates a single international price; the oil market is described as "one great pool". It depends in the short term on variations in the **rate of utilization of capacity in the Gulf countries** and, first and foremost, in the medium and long term on **the average Reserve-to-Production ratio** across the world.

The equilibrium market prices described by POLES should not be confused with prices in spot markets or long-term markets. The former are supported solely by market fundamentals, which by definition follow slow development paths. In contrast, the latter are affected mainly by developments in the financial sphere, resulting in strong price movements, stemming from parities between the dollar and other currencies, in particular the euro, and trader expectations about the future tightness of markets. All these elements do not account for fundamentals and are difficult to model.

A long-lasting high trend in the oil price cannot be explained by speculative forces alone. The sensitivity of oil supply and demand to high prices does not appear to be as high as projected, at least not over the past four years.

- On the supply side, it is to be noted that despite attractive oil prices the Gulf countries are holding back investments in production capacity and it is becoming increasingly difficult to exploit oil in non-OPEC countries, for either policy or economic reasons. The additional production capacities anticipated because of high oil prices face numerous constraints, including a protectionist stance on the part of the Gulf states, leading to limited access to resources, a shortage of skilled workers in oil services, pushing up exploration and production costs, and expectations about future market tightness.

- On the demand side, China, India and the Gulf countries have been seeing elevated oil consumption owing to their low sensitivity to oil prices.

These two points cast uncertainty on the evolution of the market fundamentals, at least for the next five to ten years (depending on how long these transitional behaviours of governments and major players last), as reflected in the recent sharp decline in oil prices in December 2008 as compared with July 2008.

➢ *Evolution of the international oil price in the Baseline scenario*

Figure 10, below, illustrates the resulting trajectory of prices. This projection indicates a slow fall in international oil prices over the period 2007-2018. This assumes a cut-back in subsidies in Asian countries like India or China and even the oil-producing countries and therefore growing sensitivity of demand to price. Furthermore, this trend is linked to the rapid development of production capacities, particularly in non-OPEC countries. In this scenario the Gulf states are assumed to produce what the market needs, with no political decisions on restricting production capacities to keep prices high. The tension between supply and demand stretches, inducing a slight decrease in oil prices. From 2018 onwards, non-OPEC production declines and the oil price rises.

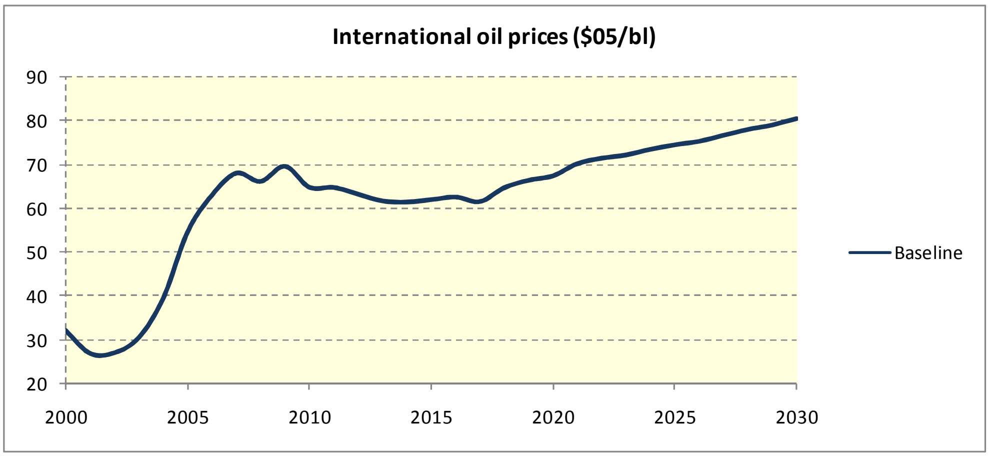

Figure 10: International oil prices – Baseline scenario

➢ *Impact on oil price of European legislation on new cars*

In the Baseline scenario global oil demand totals about 4885 Mtoe in 2030. In the most constrained scenario savings in that year equal about 50 Mtoe, **representing a 0.9% reduction in global oil demand**.

This induces **an international oil price decrease of 1.2%**, from 80€/bl to 79€/bl.

Consequently, **the implicit reactivity of the oil price to the global decline in oil demand appears to be 1.7 (1.6-1.8) and 1.25 (1.2% - 1.3%) by 2020 and 2030, respectively.** This reactivity is not an "elasticity" as such, as it also captures complex substitution processes between fuels and technologies and mixes short-term and long-term effects. It should be noted that this reactivity of oil price to consumption decreases over time, as the international market has more time to adjust to the evolution of European demand (hence also much lower reactivities than those that can be observed on the daily market, for instance at the end of 2008 and in early 2009).

Diffusion of European CO2 emissions standards to other regions will obviously have a far greater impact on the international oil market, most especially in fast-developing Asia.

	2000	2010	2020	2030
World oil consumption (Mtoe)				
S4	3670	4149	4737	4839
S3	3670	4151	4748	4864
Baseline	3670	4151	4757	4885
International Oil price ($05/bl)				
S4	32.0	64.7	66.8	79.4
S3	32.0	64.7	67.1	79.9
Baseline	32.0	64.7	67.3	80.3
Evolution World oil consumption				
S4 / Baseline	0.0%	0.0%	-0.4%	-0.9%
S3 / Baseline	0.0%	0.0%	-0.2%	-0.4%
Evolution oil price				
S4 / Baseline	0.0%	-0.1%	-0.7%	-1.2%
S3 / Baseline	0.0%	0.0%	-0.3%	-0.5%
Reactivity of oil price to World oil cons				
Reactivity S4	n.s.	n.s.	1.6	1.3
Reactivity S3	n.s.	n.s.	1.8	1.2

Table 5: Reactivity of oil price to world oil consumption

4.2 European energy bill

As stated previously, EU-27 fuel imports are set to rise steadily. Such a measure is thus very important in order to reduce energy bills by reducing oil consumption. The study indicates that in 2030, the European energy bill will be €396 billion, €397 billion, €381 billion and €368 billion in the Baseline scenario and Scenarios 2, 3 and 4, respectively.**This means that thanks to the CO2 emissions reduction in the scenario with the most aggressive legislation the economic benefits for the EU27 will amount to €28 billion in 2030 (compared with the Baseline)**, which is **a 7% decrease on the bill paid today.**

This focus on the oil bill points to a greater economic benefit. **Expenditure on oil imports in Scenario 4 decreases by 12 % in 2030** compared with the Baseline scenario. These results are presented in Table 11, in Appendix 2.

In 2007 the fuel burned by European cars and vans represented €78 billion of oil imports. In the Baseline this expenditure decreases steadily to €68 billion by 2020, subsequently rising to €76 billion by 2030. In Scenario 3 the budget for light-duty vehicles decreases by 7% in 2020 and by 18% in 2030 compared with the Baseline for these years. In Scenario 4 the savings via light-duty vehicles become more significant: a 14% reduction in 2020 compared with the Baseline and a 36% reduction in 2030.

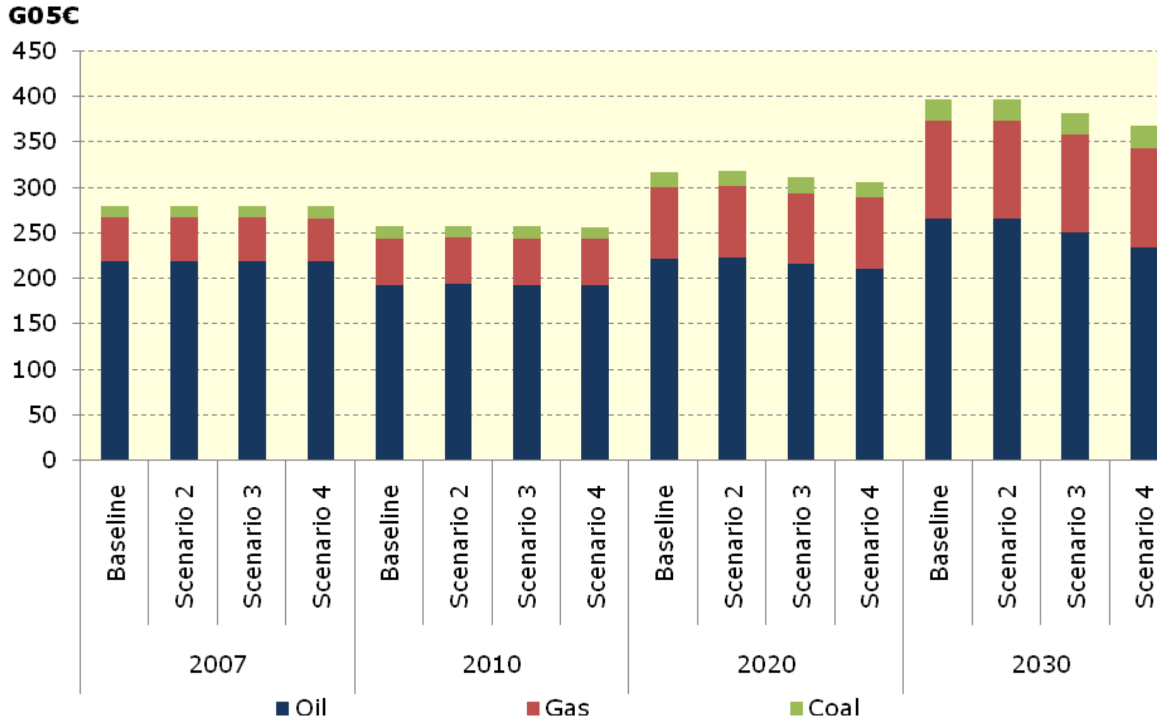

Figure 11: Energy bill for the EU27

Table 6, below, shows the evolution of fossil fuel imports compared with the Baseline situation. As can be seen, **in Scenario 4 oil imports are reduced in volume terms by 11% in 2030. This decrease thus represents 90% of the gains on the European oil bill** (86% in 2010), which amount to 31 G€ in 2030 in Scenario 4, -12% compared with the Baseline (see above and Table 7 below). The remaining 9-14% (depending on the scenario and the year considered) of these gains are consequently due to a slightly lower oil price (see below: 3.2.3).

	2010				2020				2030			
Mtoe	Bas.	S2	S3	S4	Bas.	S2	S3	S4	Bas.	S2	S3	S4
Fossil fuels	873	100%	100%	100%	1050	100%	99%	98%	1173	100%	98%	97%
Oil	504	100%	100%	100%	557	100%	98%	96%	559	100%	95%	89%
Gas	220	100%	100%	100%	331	100%	100%	101%	407	100%	101%	102%
Coal	148	100%	100%	100%	163	100%	100%	101%	207	100%	102%	105%

Table 6: Fossil fuel imports: comparison between scenarios (Scenario / Baseline)

	2010				2020				2030			
	Bas.	S2	S3	S4	Bas.	S2	S3	S4	Bas.	S2	S3	S4
Oil bill (G05€)	193	194	193	192	221	223	216	210	265	266	250	234
Oil Price ($05/bl)	52.2	52.2	52.2	52.1	54.3	54.3	54.1	53.9	64.8	64.8	64.4	64.0
Imports (Mtoe)	504	506	504	502	557	559	544	532	559	560	529	499
Contribution of reduced imports	-	-	-	86%	-	-	87%	87%	-	-	91%	90%
Contribution of reduced price	-	-	-	14%	-	-	13%	13%	-	-	9%	10%
Potential underestimation of savings*	-	-	-	-17%	-	-	-15%	-16%	-	-	-10%	-12%

Table 7: Contributions to European oil bill reduction

** Contributions to oil bill reductions calculated as follows: d(Oil Bill) / Oil Bill = d(Price)/Price + d(Imports) / Imports*

Table 7 shows that the typical method used for calculating fuel cost savings, with no allowance being made for the impact of subsequently lower oil prices (*), therefore underestimates the true savings on European energy costs by 10-17% (1/91% - 1/85.6%).

This underestimate would be higher for large consuming regions and lower for others, depending in fact on their impact on the international oil price.

In addition, it is to be noted that an even lower demand, for instance due to the adoption of similar standards in other countries, will lead to an even lower price, and consequently to a greater contribution of price decrease to the lower oil bill.

5. Potential criticisms

5.1 Methodology

- The CO2 emissions of newly sold cars have an impact on the unit consumption of new ICE vehicles only.
- The unit consumptions of alternative vehicles (plug-in hybrids and electric) are taken to be exogenous and are disconnected from those of conventional vehicles.
- The proportion of oil consumed in a plug-in hybrid electric vehicle is held constant (around 67% of the total energy consumed).
- CO2 emissions are defined as direct emissions from oil combustion; biofuel production is assumed carbon-free, for instance.
- The CO2 content of oil used for road transport is taken constant over the simulation period.
- All countries converge to the same objective in terms of average CO2 emissions per km regardless of their current emission level.
- The development of biofuels on the European market does not depend on specific car legislation, not considered in this study, but only on relative fuel prices (oil vs. biofuels).
- CO2 emissions are modelled as a linear trend to the target year; thereafter, POLES takes charge of emission and consumption profiles.

5.2 Technological options

As stated previously, inter-vehicle competition depends on the investment cost and variable cost of each vehicle type. The variable cost is calculated from fuel price and unit consumption. The investment cost of conventional vehicles consists of an additional cost, leading to greater development of alternative vehicles in the case of strong constraints on the CO2 emissions of new cars. The data adopted in the model are therefore crucial and can radically change the composition of the car fleet. Dedicated sources are listed below.

- Unit consumption of conventional vehicles: Enerdata databases (including the ODYSSEE database: http://www.odyssee-indicators.org/database/database.php)
- Unit consumption of alternative vehicles: TECHPOL database, developed at the LEPII-CNRS institute in Grenoble.
- Investment costs: TECHPOL database.
- Extra costs for conventional vehicles: study as part of the PREDIT project.

5.3 Policies

This study focuses solely on cars and light trucks, thus ignoring possible legislation on heavy vehicles, which currently account for 30% of road transport oil consumption.

Furthermore, we ignore car exports and imports to and from Europe and the subsequent potential influence of European legislation on other parts of the world, in particular Asia, where the development of road transport is becoming a key driver of future world oil consumption.

Taking these elements into account would have induced a far more significant impact of CO2 targets on oil markets. As a consequence, the benefits to the EU-27 in terms of its energy bill in particular would have been more significant.

6 Conclusions

The four scenarios considered in this study all yield a growing total CO2 emissions profile in the EU-27, even in Scenario 4. They nevertheless indicate that a reduction of road transport sector emissions is feasible: indeed, even in the Baseline scenario and in Scenario 2 (the two with the lowest constraints on CO2 emissions from cars) emissions decrease over the simulation period. In Scenario 4, with an 18% CO2 reduction relative to 2007, this is obviously more important than in the Baseline, with a reduction of only 3%. These savings are fostered mainly by car manufacturers and by strong development of alternative vehicles, in particular plug-in hybrids and electric cars. It is not biofuels that are responsible for this decrease, as no dedicated policy on these fuels was modelled in POLES for this study.

There are two reasons the European energy bill is set to grow over the coming years: greater demand and a decline in domestic resources. The main interest of the present study is thus to assess the savings to be achieved by means of more aggressive legislation on vehicle energy efficiency. The results indicate that compared with the Baseline scenario €30 billion can be saved in 2030 by introducing emission legislation on cars and light-duty vehicles. This is a significant sum, representing almost 30% of the sector's current energy consumption budget. Depending on the scenario and the year considered, 84-91% of these savings would derive from a decrease in the import volume and 9-14% from lower international oil prices resulting from these European CO2 standards. Diffusion of such standards to other world regions will definitely lead to an even lower oil price and thus ditto oil bill for Europe (and a greater contribution of price decrease to this reduction). This shows that ignoring the impact of the lower oil prices induced by lower European demand therefore underestimates the true savings in European energy costs by 10-17% (depending on the scenario and the year considered). This underestimation will be greater for large consuming regions and lower for others. It should also be noted that this underestimation of energy cost benefits only applies to measure that improve energy efficiency. Measures that stimulate alternative fuel, i.e. reduce demand for oil but increase demand for an alternative fuel like biofuel, might reduce oil prices on the one hand, but it should equally be taken into account that the price of the alternative fuel could increase as a result of the measure.

Despite the major impact at the European level, global effects are less visible. Setting aggressive emission limits in the road transport sector will reduce aggregate world oil consumption by only 1% by 2030. Even though the resulting evolution of the international oil price appears only moderate (-1.2% in 2030 between the Baseline and Scenario 4, much less than potential volatility by that time), it still implies an implicit reactivity of the oil price to the evolution of demand of 1.6-1.8 in 2020 and 1.2-1.3 in 2030, respectively (depending on the scenario concerned).

This study has not taken into account the potential influence of European legislation on other parts of the world, in particular on Asia, where the development of road transport is becoming a key driver of world oil demand. Taking this into account would strongly increase the impact of European legislation on vehicle CO2 emissions on world oil prices. As a consequence, the economic benefits for the EU-27 would be correspondingly significantly higher that identified in this study.

Finally, it should be noted that although the focus of this study was on the impacts of CO2 standards for road vehicles, the same general conclusions on oil imports and oil prices would also hold for equivalent measures on vehicle oil consumption and fuel efficiency.

Appendix 1: Modelling the car fleet

Total energy consumption is calculated as:

Energy consumption = VKm * Cons per VKm

The model calculates the average consumption per vehicle (toe/km):

Cons per VKm = f(consumption of new cars)

Calculation of VKm is performed in 2 steps:

1. First the model calculates the total number of VKm:

VKm Tot (vehicles – km) = Cars * Km per car

with: ***Cars*** = Cars pc * Population

Cars pc = f(GDP pc, EYpcc) : equipment level

EYpcc : elasticity to GDP pc = f(saturation level)

Km per car = f(average fuel price, ES) * g(cars pc,EYkm)

ES : short-term price elasticity

EYkm : elasticity to Cars pc

2. Competition is then between 5 different types of vehicles on the new equipments (new VKm + scrapped VKm) (same general putty-clay principle of substitution):

ICE : oil, biofuel

Electrical : electricity

Plug-in Hybrids : oil, biofuel, electricity

Hydrogen Fuel Cell : hydrogen

Hydrogen ICE : hydrogen

For each type of vehicle i:

$$\textbf{New VKM}_{(i)} = \textbf{New VKM tot * Market share}_{(i)}$$

with : Market share = f(annual cost to user, infrastructure coef)

Appendix 2: Detailed results

Scenarios:

- **Baseline scenario: 130 gCO2/km in 2012**
- **Scenario 2: 130 gCO2/km in 2015**
- **Scenario 3: 130 gCO2/km in 2012 and 95 gCO2/km in 2020**
- **Scenario 4: 120 gCO2/km in 2012, 80 gCO2/km in 2020 and 60 gCO2/km in 2025**

Table 8: Assumptions of the four scenarios

	2007	2010	2020	2030
Population (millions)	491	492	493	490
GDP per capita (€/cap)	28210	30516	37841	45154

Table 9: Composition of European car fleet

		Type of vehicle			
		Conventional	Hybrid	Electric	Hydrogen
2007	*Baseline*	100%	0%	0%	0%
	Scenario 2	100%	0%	0%	0%
	Scenario 3	100%	0%	0%	0%
	Scenario 4	100%	0%	0%	0%
2010	*Baseline*	100%	0%	0%	0%
	Scenario 2	100%	0%	0%	0%
	Scenario 3	100%	0%	0%	0%
	Scenario 4	100%	0%	0%	0%
2020	*Baseline*	97%	2%	1%	0%
	Scenario 2	97%	2%	1%	0%
	Scenario 3	96%	3%	1%	0%
	Scenario 4	93%	4%	2%	1%
2030	*Baseline*	87%	8%	4%	1%
	Scenario 2	88%	8%	4%	1%
	Scenario 3	81%	11%	5%	2%
	Scenario 4	66%	21%	10%	3%

Table 10: Investment cost per vehicle type

Investment costs in 2010				
In $	Baseline	Scenario 2	Scenario 3	Scenario 4
Conventional	24868	24707	25227	25324
Plug-in hybrid	45573	45576	45575	45569
Electric	54375	54378	54377	54370
Hydrogen fuel cell	544998	544998	544998	544998
Hydrogen combustion	35053	35053	35053	35053

Investment costs in 2020				
In $	Baseline	Scenario 2	Scenario 3	Scenario 4
Conventional	24800	24862	29000	33026
Plug-in hybrid	36319	36344	36306	36118
Electric	44120	44162	44106	43816
Hydrogen fuel cell	325760	325760	325760	325760
Hydrogen combustion	33592	33592	33592	33592

Investment costs in 2030				
In $	Baseline	Scenario 2	Scenario 3	Scenario 4
Conventional	24711	24765	28831	38716
Plug-in hybrid	33220	33221	33166	33034
Electric	39539	39542	39452	39240
Hydrogen fuel cell	207384	207380	207384	207339
Hydrogen combustion	32825	32825	32825	32825

Table 11: Full cost (investment + variable cost) per vehicle type

Full cost per km ($/km) in 2010				
In $/km	Baseline	Scenario 2	Scenario 3	Scenario 4
Conventional	0.37	0.37	0.38	0.38
Plug-in hybrids	0.53	0.53	0.53	0.53
Electrical	0.59	0.59	0.59	0.59
Hydrogen fuel cell	5.64	5.63	5.64	5.64
Hydrogen combustion	0.49	0.49	0.49	0.49

Full cost per km ($/km) in 2020				
In $/km	Baseline	Scenario 2	Scenario 3	Scenario 4
Conventional	0.36	0.36	0.39	0.43
Plug-in hybrid	0.43	0.43	0.43	0.43
Electric	0.48	0.48	0.48	0.48
Hydrogen fuel cell	3.38	3.38	3.38	3.38
Hydrogen combustion	0.48	0.48	0.48	0.48

Full cost per km ($/km) in 2030				
In $/km	Baseline	Scenario 2	Scenario 3	Scenario 4
Conventional	0.36	0.36	0.38	0.48
Plug-in hybrid	0.40	0.40	0.40	0.40
Electric	0.44	0.44	0.44	0.43
Hydrogen fuel cell	2.18	2.18	2.18	2.17
Hydrogen combustion	0.46	0.46	0.46	0.46

Table 12: Road vehicle fuel and energy consumption

Baseline

Mtoe	2007			2010			2020			2030		
	Total road	**Cars**	**Light trucks**	**Total road**	**Cars**	**Light trucks**	**Total road**	**Cars**	**Light trucks**	**Total road**	**Cars**	**Light trucks**
Total consumption	293	169	42	292	167	42	288	148	46	284	135	48
% of total final consumption	*22.7%*	*13.1%*	3.2%	*22.5%*	*12.9%*	3.3%	20.2%	*10.4%*	3.3%	18.9%	*9.0%*	3.2%
Oil	287	165	41	287	164	41	279	142	44	266	123	44
% of final oil consumption	*49.5%*	*28.5%*	7.1%	*49.9%*	*28.5%*	7.2%	46.2%	*23.5%*	7.4%	45.4%	*21.1%*	7.5%
Electricity	0	0	0	0	0	0	1	1	0	6	4	1
% of final electricity consumption	*0.0%*	*0.0%*	0.0%	*0.0%*	*0.0%*	0.0%	0.5%	*0.3%*	0.1%	1.7%	*1.0%*	0.4%
Biofuel	5	3	1	5	3	1	7	4	1	9	5	2
% of final biomass consumption	*9.0%*	*5.7%*	1.1%	*9.0%*	*5.6%*	1.4%	10.4%	*6.6%*	2.1%	10.4%	*6.5%*	2.3%
Hydrogen	0	0	0	0	0	0	1	1	0	3	2	1
% of final hydrogen consumption	*100.0%*	*11.6%*	14.6%	*100.0%*	*53.9%*	16.7%	100.0%	*73.0%*	24.8%	100.0%	*70.9%*	24.4%

Scenario 2

Mtoe	2007			2010			2020			2030		
	Total road	**Cars**	**Light trucks**	**Total road**	**Cars**	**Light trucks**	**Total road**	**Cars**	**Light trucks**	**Total road**	**Cars**	**Light trucks**
Total consumption	293	169	42	294	169	42	291	150	46	286	137	48
% of total final consumption	*22.7%*	*13.1%*	3.2%	*22.6%*	*13.0%*	3.3%	20.4%	*10.5%*	3.3%	19.0%	*9.1%*	3.2%
Oil	288	166	41	289	166	42	282	144	45	268	125	44
% of final oil consumption	*49.5%*	*28.5%*	7.1%	*50.0%*	*28.7%*	7.2%	46.5%	*23.8%*	7.4%	45.5%	*21.3%*	7.5%
Electricity	0	0	0	0	0	0	1	1	0	6	4	1
% of final electricity consumption	*0.0%*	*0.0%*	0.0%	*0.0%*	*0.0%*	0.0%	0.4%	*0.3%*	0.1%	1.7%	*1.0%*	0.4%
Biofuel	5	3	1	5	3	1	7	5	1	9	6	2
% of final biomass consumption	*9.0%*	*5.7%*	1.1%	*9.0%*	*5.6%*	1.4%	10.4%	*6.7%*	2.1%	10.4%	*6.6%*	2.3%
Hydrogen	0	0	0	0	0	0	1	1	0	3	2	1
% of final hydrogen consumption	*100.0%*	*11.6%*	14.6%	*100.0%*	*53.2%*	16.3%	100.0%	*73.3%*	24.4%	100.0%	*71.1%*	24.2%

Scenario 3

Mtoe	2007			2010			2020			2030		
	Total road	**Cars**	**Light trucks**	**Total road**	**Cars**	**Light trucks**	**Total road**	**Cars**	**Light trucks**	**Total road**	**Cars**	**Light trucks**
Total consumption	293	169	42	292	167	42	276	137	45	259	113	45
% of total final consumption	*22.7%*	*13.1%*	3.2%	*22.5%*	*12.9%*	3.3%	19.5%	*9.7%*	3.2%	17.5%	*7.6%*	3.0%
Oil	287	165	41	287	164	41	266	131	43	236	99	39
% of final oil consumption	*49.5%*	*28.5%*	7.1%	*49.9%*	*28.5%*	7.2%	45.1%	*22.1%*	7.3%	42.4%	*17.8%*	7.0%
Electricity	0	0	0	0	0	0	2	1	0	9	6	2
% of final electricity consumption	*0.0%*	*0.0%*	0.0%	*0.0%*	*0.0%*	0.0%	0.6%	*0.4%*	0.1%	2.5%	*1.5%*	0.6%
Biofuel	5	3	1	5	3	1	7	4	1	8	5	2
% of final biomass consumption	*9.0%*	*5.7%*	1.1%	*9.0%*	*5.6%*	1.4%	10.0%	*6.2%*	2.1%	9.5%	*5.6%*	2.2%
Hydrogen	0	0	0	0	0	0	1	1	0	5	4	1
% of final hydrogen consumption	*100.0%*	*11.6%*	14.6%	*100.0%*	*53.8%*	16.2%	100.0%	*73.4%*	24.8%	100.0%	*70.5%*	25.8%

Scenario 4

Mtoe	2007			2010			2020			2030		
	Total road	**Cars**	**Light trucks**	**Total road**	**Cars**	**Light trucks**	**Total road**	**Cars**	**Light trucks**	**Total road**	**Cars**	**Light trucks**
Total consumption	292	168	42	290	165	42	265	128	44	237	97	40
% of total final consumption	*22.7%*	*13.1%*	3.2%	*22.4%*	*12.8%*	3.2%	18.9%	*9.1%*	3.1%	16.3%	*6.7%*	2.7%
Oil	287	165	41	285	162	41	254	120	41	206	77	32
% of final oil consumption	*49.5%*	*28.5%*	7.1%	*49.7%*	*28.3%*	7.2%	43.9%	*20.8%*	7.1%	39.0%	*14.6%*	6.1%
Electricity	0	0	0	0	0	0	3	2	1	16	10	4
% of final electricity consumption	*0.0%*	*0.0%*	0.0%	*0.0%*	*0.0%*	0.0%	1.0%	*0.7%*	0.2%	4.2%	*2.7%*	0.9%
Biofuel	5	3	1	5	3	1	7	4	1	7	4	2
% of final biomass consumption	*9.0%*	*5.7%*	1.1%	*8.9%*	*5.5%*	1.4%	9.6%	*5.9%*	2.1%	8.5%	*4.8%*	2.0%
Hydrogen	0	0	0	0	0	0	2	1	0	9	6	2
% of final hydrogen consumption	*100.0%*	*11.6%*	14.7%	*100.0%*	*54.8%*	16.9%	100.0%	*73.1%*	25.5%	100.0%	*72.8%*	24.2%

Table 13: Road transport CO2 emissions

	2007	**2010**				**2020**				**2030**			
In Mt CO2		Bas.	S2	S3	S4	Bas.	S2	S3	S4	Bas.	S2	S3	S4
Total emissions	**4184**	**4276**	**4282**	**4276**	**4270**	**4598**	**4606**	**4562**	**4534**	**4763**	**4767**	**4690**	**4643**
Road transport	889	887	893	888	881	872	880	835	804	858	863	782	724
Direct	889	887	893	887	881	863	872	824	787	823	829	732	637
Indirect	0	0	0	0	0	9	8	11	18	34	34	50	87

Table 14: Energy independence

	2007	2010				2020				2030			
%		Bas.	S2	S3	S4	Bas.	S2	S3	S4	Bas.	S2	S3	S4
Total energy independence	**50%**	**53%**	**53%**	**53%**	**53%**	**48%**	**48%**	**48%**	**49%**	**45%**	**45%**	**46%**	**46%**
Energy consumption (Mtoe)	*1837*	*1874*	*1876*	*1874*	*1872*	*2024*	*2026*	*2011*	*2003*	*2132*	*2134*	*2111*	*2102*
Fossil fuel imports (Mtoe)	*911*	*873*	*874*	*873*	*871*	*1050*	*1053*	*1038*	*1030*	*1173*	*1175*	*1150*	*1133*
Oil	18%	23%	23%	23%	23%	17%	17%	17%	18%	13%	13%	14%	14%
Oil consumption (Mtoe)	*661*	*653*	*655*	*653*	*651*	*670*	*673*	*657*	*645*	*644*	*645*	*614*	*583*
Oil imports (Mtoe)	*544*	*504*	*506*	*193*	*502*	*557*	*559*	*216*	*532*	*559*	*560*	*250*	*499*
Gas	47%	48%	48%	48%	48%	38%	38%	38%	38%	28%	28%	28%	28%
Gas consumption (Mtoe)	*412*	*426*	*426*	*426*	*426*	*532*	*532*	*533*	*534*	*568*	*568*	*570*	*576*
Gas imports (Mtoe)	*218*	*220*	*220*	*220*	*220*	*331*	*331*	*331*	*333*	*407*	*407*	*409*	*416*
Coal	61%	63%	63%	63%	63%	62%	62%	62%	61%	56%	56%	55%	55%
Coal consumption (Mtoe)	*380*	*402*	*402*	*402*	*402*	*425*	*425*	*426*	*428*	*468*	*468*	*473*	*484*
Coal imports (Mtoe)	*149*	*148*	*148*	*148*	*148*	*163*	*163*	*163*	*165*	*207*	*207*	*211*	*218*

Table 15: Energy bill for fossil fuels

	2007	2010				2020				2030			
G05€		Bas.	S2	S3	S4	Bas.	S2	S3	S4	Bas.	S2	S3	S4
Total (oil+gas+coal)	**279**	**257**	**258**	**257**	**256**	**316**	**317**	**310**	**306**	**396**	**397**	**381**	**368**
Oil	219	193	194	193	192	221	223	216	210	265	266	250	234
dedicated to cars + LT	78	69	70	69	68	68	69	63	59	76	77	62	48
Gas	48	51	51	51	51	78	78	78	78	107	107	107	109
Coal	12	13	13	13	13	17	17	17	17	23	23	24	25